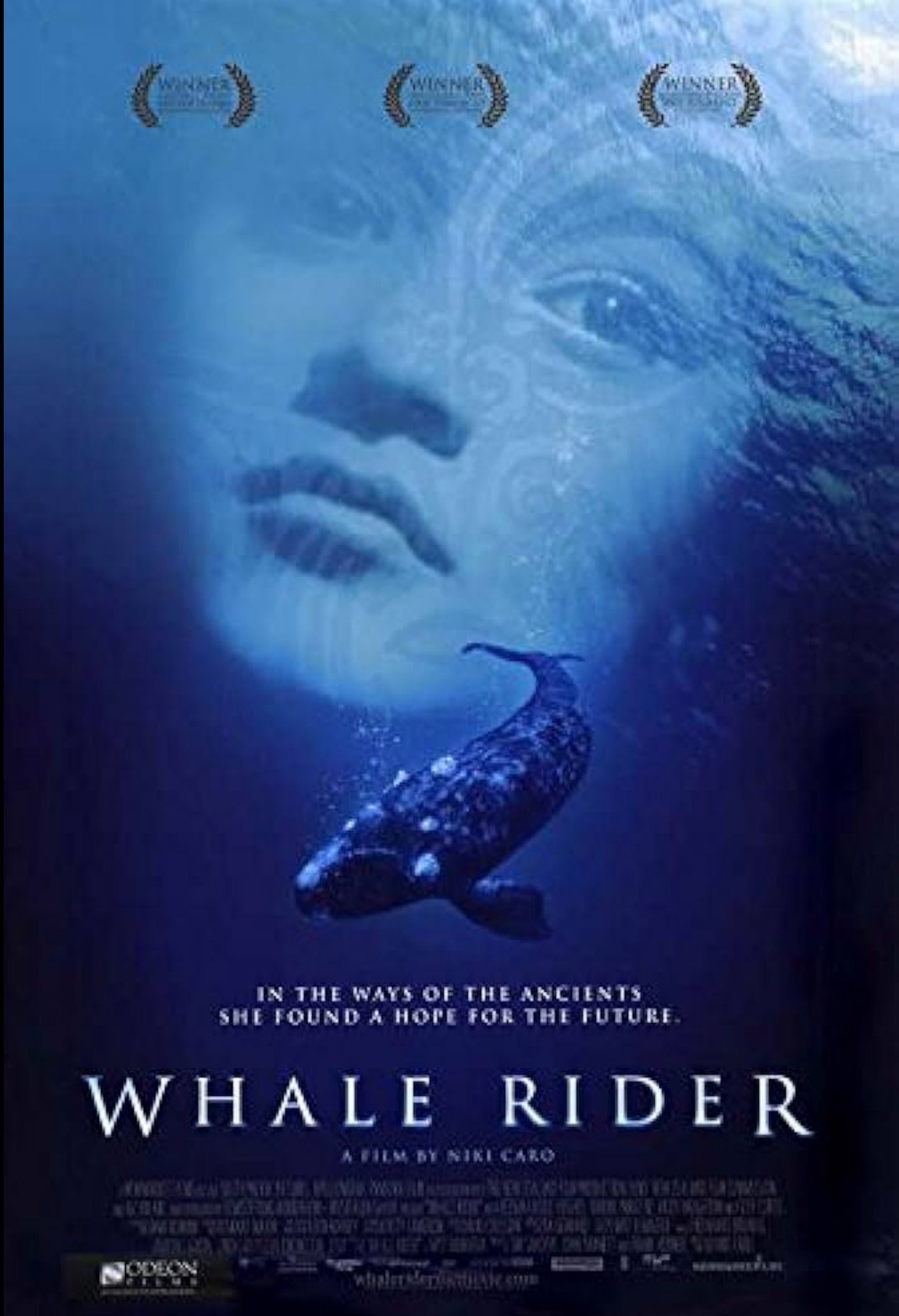

WINNER
WINNER
WINNER
IN THE WAYS OF THE ANCIENTS
SHE FOUND A HOPE FOR THE FUTURE.
WHALE RIDER
A FILM BY NIKI CARO
ODEON FILMS

Echolocation

Enduring Understandings:

- Some animals communicate, navigate and interact with their environment using senses different from those used by humans.
- Although we think it's easiest to navigate through our environment by "seeing" what's in front of us, not all creatures would find it practical to use their "eyes" like we do.
- We can organize the information we know about our environment by mapping.

Essential questions:

- What is a whale? What are some basic facts about whales?
- How does the process of echolocation work, and under what situations is this process useful?
- Why doesn't every animal "see" as we do?
- How do we create a scale map of our environment?

Notes to the Teacher:

Whales are fascinating animals about which students generally have little understanding. Are they fish or are they mammals? Do they breathe in air or in water? Studying whales gives the students the opportunity to examine the definition of a mammal and see how an animal so different from humans in fact falls into the category of mammal. In addition, the blue whale is the largest animal that has ever lived on earth, automatically making it an exciting species to study!

Understanding an animal is the first step to caring about its survival and welfare. Many species of whales are currently classified as endangered. Seeing these majestic marine animals suffering at the hands of man allows students to think about the powerful effects that we humans have over the environment and over creatures that completely dwarf us. It is only when students realize that even the largest of animals needs our compassion and assistance that they can truly appreciate the serious responsibilities that accompany the privileges man enjoys.

Activity 1 is intended to allow students to learn about species of whales and dolphins found in the South Pacific Ocean and express their learning /understanding/ feelings through an artistic medium. The key idea behind this activity is not to accumulate a checklist of facts, but to learn about whales almost effortlessly, simply by learning to read better! This lesson involves reading for information. Yes, you can see your students' eyes glazing over already, right? Wrong! This activity will allow you to explain to your students that sometimes it's natural to be bored by pages of "information" so you are going to give

them some tricks so that each group can self-monitor their "information intake." These "tricks" are really the things that curious, involved, inquisitive readers instinctively say (aloud or in their head) when they read. Many students are weak readers, and even more do a sub-par job of reading for information. By allowing students to model the internal behavior of successful students, they will learn how to interact with text, how to stop and think about what they are reading in order to make the connections necessary for comprehension and memory, and how to enjoy reading.

Activity 2 asks the students to perform precise measuring within the context of a chaotic environment, which simulates the experiences of whales in an ocean full of man-made noise pollution. The goal is not necessarily to perform the most accurate calculations, but to understand the issues that arise when one attempts to perform accurate calculations amid a "sea of noise."

To prepare for **Activity 2**, read through the activity to understand what the students will be doing. Decide how you would like to introduce students to the topic of echolocation. You may choose to photocopy the introduction for each group, or you may wish to begin with a whole-class introduction to echolocation and its social context.

Decide ahead of time which size of group is appropriate for your classroom. This activity can be done in a number of ways: smaller groups will take longer to develop their maps; larger groups will allow students to appreciate issues surrounding the "timing" of sending out clicks (i.e., if too many signals are returning at once, then it is more difficult to incorporate all the information received by the echoes). Ideal group size is likely 4 – 6 students, but groups could be of any size.

Place objects around the room as desired for students to "discover." You may wish to move traditional desks to the perimeter of the room and instead create an artificial ocean environment with, for example, one desk representing a "food source" and another desk representing an "ocean cave." If you have access to the school gym, or if weather permits for an outside lesson, you may wish to take advantage of the naturally open space.

Note: Groups will likely be able to "see" whatever objects are in their environment and will send messengers out accordingly. If you have the opportunity to place less visible objects (i.e., Ping-Pong balls in longer grass or small stickers on the gym floor) around the environment, then the task will become a little more difficult, and perhaps more fun.

Duration of Lesson:

Two periods

Assessment:

Student discussion
Student maps
Student calculation of distances and scales

Standards
Indicators addressed by this lesson

Standard 5. Understands the structure and function of cells and organisms

Level III [Grade: 6-8]

4. Knows that multicellular organisms have a variety of specialized cells, tissues, organs, and organ systems that perform specialized functions (e.g., digestion, respiration, reproduction, circulation, excretion, movement, control and coordination, protection from disease)

5. Knows that organisms have a great variety of body plans and internal structures that serve specific functions for survival (e.g., digestive structures in vertebrates, invertebrates, unicellular organisms, and plants)

6. Knows how an organism's ability to regulate its internal environment enables the organism to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment

7. Knows that organisms can react to internal and environmental stimuli through behavioral response (e.g., plants have tissues and organs that react to light, water, and other stimuli; animals have nervous systems that process and store information from the environment), which may be determined by heredity or from past experience

Standard 6. Understands relationships among organisms and their physical environment

Level III [Grade: 6-8]

2. Knows factors that affect the number and types of organisms an ecosystem can support (e.g., available resources; abiotic factors such as quantity of light and water, range of temperatures, and soil composition; disease; competition from other organisms within the ecosystem; predation)

Standard 9. Understands the sources and properties of energy

Level III [Grade: 6-8]

7. Knows that vibrations (e.g., sounds, earthquakes) move at different speeds in different materials, have different wavelengths, and set up wave-like disturbances that spread away from the source

Standard 10. Understands forces and motion

Level III [Grade: 6-8]

3. Knows that an object's motion can be described and represented graphically according to its position, direction of motion, and speed

5. Knows that an object that is not being subjected to a force will continue to move at a constant speed and in a straight line

Standard 12. Understands the nature of scientific inquiry

Level III [Grade: 6-8]

5. Uses appropriate tools (including computer hardware and software) and techniques to gather, analyze, and interpret scientific data

7. Knows that scientific inquiry includes evaluating results of scientific investigations, experiments, observations, theoretical and mathematical models, and explanations proposed by other scientists (e.g., reviewing experimental procedures, examining evidence, identifying faulty reasoning, identifying statements that go beyond the evidence, suggesting alternative explanations)

Materials needed:

For each group, you will need:

- Pencils/erasers
- Ruler
- Protractor
- At least one stopwatch or watches/clocks that display seconds
- **Handout 1: Fact Sheet – What Is a Whale?**
- **Handout 2: Student Introduction to Echolocation**
- **Handout 3: Instructions for the Echolocation Activity**
- **Handout 4: Average Walking Speed**
- **Handout 5: Establishing a Scale**
- **Handout 6: Calculating Distances**
- 3-4 sheets of blank paper

(**Note:** Depending on the time available and the ability level of your students, you may wish to follow the instructions on **Handout 5** yourself and provide ready-made copies of map templates with pre-made scales (instead of blank paper). More advanced groups or groups with more time should be able to create their own maps directly from blank sheets of paper with the aid of this handout.)

Procedure

Activity 1: Learning About Whales

1. Introduce the topic of whales by asking students what they already know about whales. ("Who can tell me something about a whale?" or "What do you think of when you think of whales?" are two possible questions to get the discussion started.)

2. Distribute **Handout 1: Fact Sheet – What Is a Whale?** and allow students to read the information together in groups. As it can be easy for students to simply gloss over printed information, each group should be encouraged to read *for information*, that is, with the goal of truly understanding and taking in the information presented. Explain to your students that sometimes it's natural to be bored by pages of "information" so you are going to give them some tricks so that each group can self-monitor their "information intake." The tricks are:

   a. Really?!?! – encourage group members to periodically stop after reading a fact and exclaim, "Really?!" This will force the group to stop and think about what they've just read. Upon hearing a group member say, "Really?!" the entire group must stop and think about the significance of what they've just read. Is it surprising? Is it cool? Is it scary? Is it disgusting?

   b. I never knew that! – Any student at any point in time may say, "I never knew that!" at which point the rest of the group must, in turn, say whether or not they knew that. If students know something

related to the fact, they should share what they do know, and how they know it/where they learned it.

c. What does that mean? – Students should be encouraged to ask, "What does that mean?" whenever they find themselves thinking it. Then, the group must stop and try to come to a conclusion so that everyone understands what the phrase or sentence means.

d. That makes me think of . . . – At any point during the reading activity, a student may call out, "That makes me think of. . . " at which point, at least two or three group members should share what tangential thoughts come to mind as a result of what the group just read.

Let the students know that reading doesn't necessarily have to be a *quiet* activity. In fact, when reading for information, the more dialogue the better. The more students discuss the information, the better opportunity for comprehension and later recall.

3. If a final product is desired, each group can create something to hang on the wall that represents their experience during the activity. It can be a word map, an artistic creation, a list of facts . . . anything that can be displayed visibly as a reminder of what they have read. The product can represent facts, new vocabulary, or even emotions associated with the day's learning.

4. Allow groups to present their product, if desired, or simply display the products and allow "viewing time" so that groups can look at each other's work.

Activity 2: Echolocation

1. Place the class into groups. Each group should have a "center" from which to create their maps with all student materials at the center.

2. Introduce the topic of echolocation using the material in the **Notes to the Teacher** section. This may be done as a whole-class activity (teacher-led introduction) or by giving copies of **Handout 2: Student Introduction to Echolocation** to each group. Encourage questions and discussion at this stage. Explain to your students that they will be imitating the process of echolocation by each becoming "clicks and echoes" and navigating through an "ocean environment" for the purpose of creating a scale map of the ocean.

3. Go through **Handout 3: Instructions for the Echolocation Activity**. Depending on the ability of your class, you may wish to read through the instructions with the class as a whole or let each group read the instructions on their own. Invite them to ask for help or clarification as they need it.

4. Calculate Average Walking Speed. Groups will begin by determining each member's average walking speed, as instructed on **Handout 4: Average Walking Speed.**

5. Decide who does what. Each group should choose a main "navigational coordinator" who will be responsible for sending out the clicks. Depending on the size of the groups, you may wish to have two students work together in this role, taking turns. Students may wish to assign different tasks to different group members (one calculates distance, one converts to a scale distance, one locates on the map) or the group can

work as a team to accomplish these goals with any division of labor that seems appropriate.

6. Establish the timing routine. The navigational coordinator will select messengers and tell them in which directions to travel. The navigational coordinator (or an assistant) will record the exact time the messenger leaves the center (including seconds). Alternatively, students can use a stopwatch to determine the length of time between a messenger's departure and arrival. If you choose to have students keep track of arrival and departure times, then several messengers can be out at the same time; however, students will have to perform the added calculation of determining the length of time the messenger was away from the center. If you choose to have students use stopwatches (recommended only if the added calculation is seen as too difficult or time consuming), then one stopwatch per messenger is required. Students will then not need to calculate elapsed time.

7. Send out the "clicks." Messengers acting as "clicks" must travel in a straight line until they hit an object (any object, including another messenger) at which point they turn around and head back along the same path. As they are walking back toward the center, they represent echoes.

8. Have the navigational coordinator record the exact time (including seconds) of the echo's return. The echo will inform the navigational coordinator, to the best of his ability, what object he hit that forced him to bounce back. (NOTE: Some objects may be unknown, especially if it was another "messenger" that reflected the click.)

9. Have students calculate the distance traveled by the click. The navigational coordinator (or the messenger) can be responsible for determining the distance between the whale center and the object, using the equation *distance = speed x time*

10. Convert the actual distance to a scale distance. Instructions are on **Handout 5: Establishing a Scale** and **Handout 6: Calculating Distances**.

11. Have students plot their findings on the map. The group should place the object on the map at a suitable distance and direction from the whale center.

12. Continue to send out multiple clicks. The group continues mapping the environment by sending out multiple messengers in all directions. The group may wish to send messengers out in the same direction more than once to "double check" their findings. The group can experiment with the timing of sending out messengers – too many messengers at once can lead to confusion when they all return at the same time; too few messengers leads to a very slow accumulation of data.

13. You may specify a time limit to this activity, in which case students will map as much of the environment as they can. Alternatively, you can decide that students are "finished" when they have mapped a minimum number of objects, or a certain defined list of objects. (Although the map is a key component of this exercise, remember that the goal is to experience the process of mapping through echolocation. Having a few items mapped accurately and having gained an appreciation of the form of mapping is just as desirable an outcome as having a completed map.)

14. Allow students the opportunity to discuss, either in small groups or as a whole class, their experiences. Be sure to cover the Discussion Questions at the end of **Handout 3**.

Extension Activities:

1. Have students research the problem of noise pollution as it relates to whales and their environment. Students can write a concerned letter expressing the need to control noise pollution.

2. Have students research other animals that rely on sonar-type communication and/or navigation systems (e.g., bats).

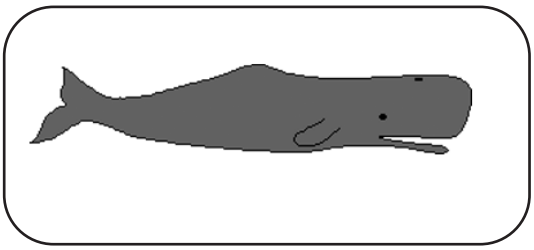
3. Have students hold a debate on the issue of government/military use of water space (for defense or for research) that negatively affects marine life.

4. Not all whales use echolocation. Students can research to compare and contrast those that do vs. those that do not use echolocation. What specific features do echolocation whales have that other whales do not? Where do whales with echolocation live compared with where other whales live? Why might they have developed this way, in this area?

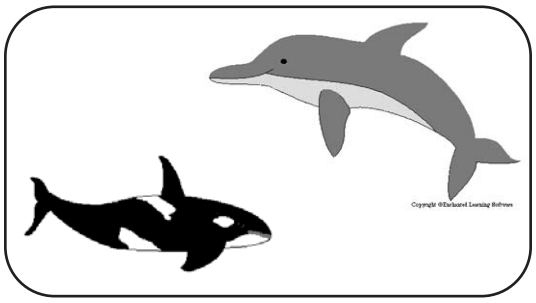
HANDOUT 1 ▸ P. 1 FACT SHEET – What Is a Whale?

Living in the Ocean

Whales are large, magnificent, intelligent, aquatic mammals. They breathe air through blowhole(s) into lungs (unlike fish, which breathe using gills). Whales have sleek, streamlined bodies that move easily through the water. They are the only mammals, other than manatees (seacows), that live their entire lives in the water, and the only mammals that have adapted to life in the open oceans.



Whales breathe air. They are NOT fish. They are mammals that spend their entire lives in the water.



Cetaceans are the group of mammals that includes the whales, dolphins, and porpoises.

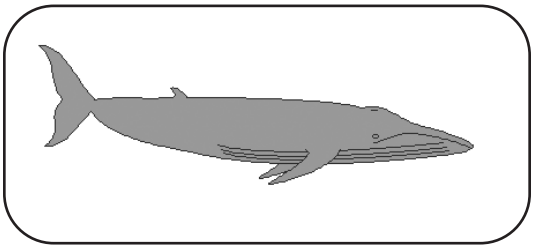
Like all mammals:

- Whales breathe air into lungs.
- Whales have hair (although they have a lot less than land mammals, and have almost none as adults),
- Whales are warm-blooded (they maintain a high body temperature).
- Whales have mammary glands with which they nourish their young.
- Whales have a four-chambered heart.

Size

The biggest whale is the blue whale, which grows to be about 94 feet (29 m) long – the height of a 9-story building. These enormous animals eat about 4 tons of tiny krill each day, obtained by filter feeding through baleen. Adult blue whales have no predators except man.

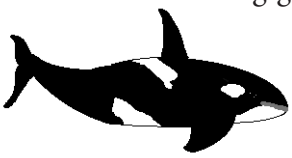
The smallest whale is the dwarf sperm whale, which as an adult is only 8.5 feet (2.6 m) long.



The blue whale is the largest animal that has ever existed on Earth. It is larger than any of the dinosaurs were. It's also the loudest animal on Earth.

Two Types of Cetaceans

Cetaceans include the whales, dolphins and porpoises. There are over 75 species of Cetaceans. Whales belong to the order Cetacea (from the Greek word "ketos," which means whale), which is divided into the following groups:



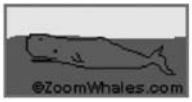
Toothed whales (Odontoceti) – predators that use their peg-like teeth to catch fish, squid, and marine mammals, swallowing them whole. They have one blowhole (nostril) and use echolocation to hunt. There are about 66 species of toothed whales.

Baleen whales (Mysticeti) – predators that sieve tiny crustaceans, small fish, and other tiny organisms from the water with baleen. Baleen is a comb-like structure that filters the baleen whales' food from the water. Baleen whales are larger than the toothed whales and have 2 blowholes (nostrils). There are 10 species of baleen whales.

Swimming and Other Water Activities

Whales have a streamlined shape and almost no hair as adults (it would cause drag while swimming). Killer whales and Shortfin Pilot whales are the fastest, swimming up to 30 miles per hour (48 k/h).

Whales swim by moving their muscular tails (flukes) up and down. Fish swim by moving their tails left and right.



Breaching: Many whales are very acrobatic, even breaching (jumping) high out of the water and then slapping the water as they come back down. Sometimes they twirl around while breaching. Breaching may be purely for play or may be used to loosen skin parasites or have some social meaning.

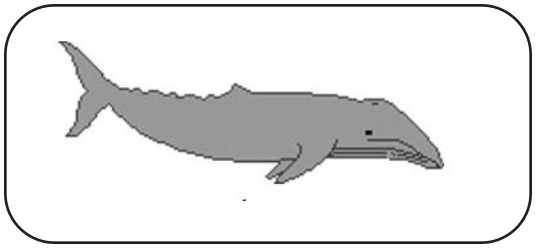
Spyhopping: This is another cetacean activity, in which the whale pokes its head out of the water and turns around, perhaps to take a look around.

Lobtailing: Some whales stick their tail out of the water into the air, swing it around, and then slap it on the water's surface; this is called lobtailing. It makes a very loud sound. The meaning or purpose of lobtailing is unknown, but may be done as a warning of danger to the rest of the pod.

Logging: Logging is whate a whale does when it lies still at the surface of the water, resting, with its tail hanging down. While it floats motionless, part of the whale's head, the dorsal fin or parts of the back are exposed at the surface.

Migration

Many ceteaceans, especially baleen whales, migrate over very long distances each year. They travel, sometimes in groups (pods), from cold-water feeding grounds to warm-water breeding grounds.



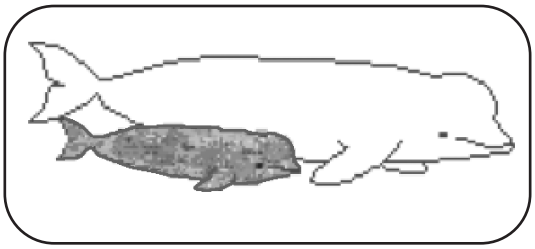
Gray whales make the longest seasonal migration of any of the whales. They travel about 12,500 miles each year

Social Behavior

Cetaceans have very strong social ties. The strongest social ties are between mother and calf. A social group of whales is called a pod. Baleen whales travel alone or in small pods. The toothed whales travel in large, sometimes stable pods. The toothed whales frequently hunt their prey in groups, migrate together, and share the care of their young.

Reproduction

Cetaceans give birth to live young, which are nourished with milk from their mothers – they don't lay eggs. Cetaceans breed seasonally, usually in warm tropical waters, and females usually have one calf every 1-3 years. The gestation times range from 9 to 18 months. Whale calves can swim at or soon after birth. Mother whales care for their young for an extended period of time, usually at least a year, feeding them milk and protecting them.



Young cetaceans are frequently mottled in color, camouflaging them from predators. Newborns have a sparse covering of hair, which they lose as adults.

Whale Songs

Complex whale songs can be heard for miles under the water. The humpback's song can last for 30 minutes. Baleen whales sing low-frequency songs; toothed whales emit whistles and clicks that they use for echolocation. The songs are thought to be used in attracting mates, to keep track of offspring, and, for the toothed whales, to locate prey.

Classification of Cetaceans

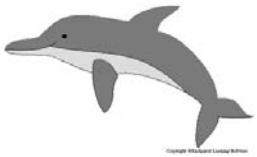
Cetaceans are divided into the following suborders:

killer whales or orcas

beluga whales

Odontoceti (toothed whales) narwhals

sperm whales



the beaked whales, dolphins , and porpoises

Mysticeti (mustached whales) or baleen whales - blue whales

humpback whales

gray whales

bowhead whales

minke whales

Primitive Whales and Evolution

Primitive whales evolved during the mid-Eocene period, about 50 million years ago. Fossil remains indicate that whales evolved from hoofed land mammals – perhaps the shore-dwelling, hyena-like Mesonychid that returned, bit by bit, to the sea roughly 50 million years ago.

Another possible step in whale ancestry is the otter-like Ambulocetus, an extinct mammal the size of a sea lion, 10 feet (3 m) long and about 650 pounds. Its limbs allowed it to swim and could also support it on land. It had long, powerful jaws with shark-like teeth, a small brain, and a pelvis fused to its backbone (like land-dwelling mammals but unlike whales).

Basilosaurus, a very primitive, extinct whale had a tiny head and pointed snout with teeth, unlike modern-day whales, which have large heads and a blunter snout. It was about 82 feet (25 m) long.

Endangered Whales

There are many species of whales that are in danger of going extinct. Most baleen whales (the huge whales targeted by commercial whalers) are listed as endangered or protected species. These large whales are filter feeders and are among the largest animals on earth. They have baleen plates instead of teeth, which are used to filter tiny organisms, like krill and small fish, from the water. They use their tongue to dislodge the food from the baleen and swallow it. Baleen is made of keratin, the same protein that our hair and nails are made of. Most other whale species are doing well and are not endangered.

Handout 2 Student Introduction to Echolocation

Background: Echolocation is the way in which some species of animals see, hear and speak. These animals are able to send out signals and time how long it takes for them to receive an echo back. Whales send out sounds called "clicks" which transmit easily through water until they hit an object. At that point, the click is reflected back to the whale in the form of an "echo." When whales receive echoes, they are able to determine the position, size and nature of objects in their environment. Echolocation compensates for the difficulty whales have seeing in the dark, dim oceans.

Social Context: Researchers often use the unique skills of other species to improve our own technology. Human-made echolocation is known as sonar. Organizations like the U.S. Navy use sonar to monitor the oceans for submarine activity. The types of frequencies that are best able to detect foreign submarines at a great distance are the same types of frequencies emitted by whales to navigate, communicate and find food. Some believe that whale communities are suffering because this "noise pollution" distorts the whale's own signals and leads to miscommunication and an inability to navigate properly. Human activity such as drilling, shipping and submarine activity has also led to noise pollution in the oceans. In addition to affecting a whale's navigation system, this ocean noise may be severely damaging to a whale's hearing system.

Lesson Objective: This lesson is intended to allow you to experience the process of echolocation as a navigation tool. As our ears are not designed to make the fine distinctions that other species can, you will imitate the process by acting as sound waves.

You and your group members will be sent out from the "whale center" as "clicks" and will continue traveling in a straight line until you are reflected back by an object in the environment. You will return following the same straight line, and your total time away from the center will be used to determine how far away you were when you hit an object. Then, this information will be used to create a scale map of the environment.

As you go through this activity, keep in mind that some whales send out several clicks per minute, and therefore they receive back several echoes per minute. A whale's brain has to interpret all these data at once, in its head, to understand what is in its surrounding environment. You will probably find that it is difficult enough with your own group out walking around – but you'll be competing for information with other groups, too. It won't always be real objects that send you back to your center – it could be other clicks that you run into. And, if you run into another student as you're on your way back to your center, then you will be forced to turn around and walk *away* again. Talk about a confusing message to bring back to the whale center!

Scientists always talk about the wonders and skills of the human brain, but after this activity, you'll certainly come to respect the abilities of whales.

Instructions for the Echolocation Activity

1. **Calculate Average Walking Speed.** Use the "Average Walking Speed" handout to determine the average walking speed of each member in your group.
2. **Choose a "whale brain."** Your group should choose a main "navigational coordinator" who will be responsible for sending out the clicks.
3. **Keeping Time.** The navigational coordinator will select messengers to act as "clicks" and will tell them in which directions to travel. He or she (or an assistant) will record the exact time the messenger leaves the center (including seconds) on the "Calculating Distances" handout using a watch or a clock. If your group has been told to use a stopwatch instead, then start the stopwatch as soon as the messenger leaves the center.
4. **Send out the clicks.** Messengers acting as "clicks" must travel in a straight line until they hit an object (any object, including another messenger) at which point they must turn around and head back along the same path, as "echoes."
5. **The echoes return.** The navigational coordinator will record the exact time (including seconds) of the echo's return, or will stop the stopwatch and record how much time has passed on the "Calculating Distances" handout.
6. **The echo reports.** The echo will inform the navigational coordinator, to the best of his ability, what object he hit that forced him or her to bounce back.
7. **Calculate the distance traveled by the click.** The navigational coordinator (or the messenger) can be responsible for determining the distance between the whale center and the object using the equation *distance = speed x time*
8. **Convert the actual distance to a scale distance.** The group must then convert the actual distance into an appropriate distance for the scale map. Instructions are on the "Establish a Scale" handout.
9. **Plot on the map.** The group should place the object on the map at a suitable distance (using a ruler) and direction (using a protractor) from the whale center.

10. **Continue to send out multiple clicks.** Continue to map your environment by sending out multiple messengers in all directions. Your group may wish to send messengers out in the same direction more than once to double check your findings. What happens if you only send out one messenger at a time? What happens if you send everyone out at once?

11. **Discussion and Conclusion.** Discuss the following questions with your group:

    - Although echolocation seems like a difficult and complicated method for humans to figure out what's in their environment, this doesn't mean that echolocation is a less effective means for gathering information. It just means that it's not effective for humans in their daily life. In fact, humans have designed technology to allow them to use echolocation in certain environments. In what ways is echolocation a good method for whales to "see" their environment? Why do you think whales developed this skill?

    - Did your group have any difficulties with this activity? If so, what interfered with your ability to use echolocation? What kinds of difficulties would whales encounter as they use echolocation? What are the possible effects of receiving corrupted information from echoes – for example, misinformation about where food is located, about where the pod is going, about where danger lies?

HANDOUT 4 Average Walking Speed

When whales use echolocation, they figure out how far away objects are, based on how long it takes their clicks to return back to them as echoes. Whales instinctively know how fast their sound waves are traveling in water. In fact, the speed that sound travels in water is approximately 1500 m/s.

To perform your echolocation activity, you will first need to figure out how quickly your sound waves (that is *you*!) travel through the environment. To do that, you will calculate your *average walking speed* as instructed below.

1. Find a clear spot in the room.
2. Mark a starting point on the floor.
3. Have another member of your group time you as you walk in a straight line for 5 seconds. Don't try to walk too quickly or too slowly. Walk at the same speed you plan to walk for the rest of the activity.
4. Measure how far in meters you walked in 5 seconds. Write this number down in your "Distance" column.
5. In your "Time" column, write down 5 seconds. (Note: If you ran out of space walking for 5 seconds, then you can always walk for a shorter time. Just make sure that you write down the actual number of seconds you walked in the time column.)
6. Fill in the "speed" column using the formula *speed = distance ÷ time*
7. Find the speed for every member of your group.

Name	Distance (m)	Time (s)	Speed (m/s) = distance ÷ time

HANDOUT 5 ▸ P. 1 Establishing a Scale for Your Map

Your map can't be life-sized, but it can be *proportional*, or *to scale*. This means that your map will be a miniaturized version of the classroom. So, if the "food source" is twice as far away from your whale center as the "Navy Submarine" in your classroom, then the "food source" will also be twice as far away from your whale center as the "Navy Submarine" on your map.

Scales are used in all maps, because no map can be life-sized. For a map of a country, 1cm on the map might represent 100 km. For a map of a city, 1 cm might represent 1km. For your map, 1cm will probably represent 1 to 3 meters, depending on the size of your "ocean." Some quick calculations can help establish a good scale for your map.

In your groups, or with the help of your teacher, you will need to measure:

1. The length of your "ocean" in meters
2. The width of your "ocean" in meters
3. The length of your piece of paper in centimeters
4. The width of your piece of paper in centimeters

Remember, although you will want to show your whole ocean on your page, you do not have to use your entire page. For example, if your ocean is 20 m long and 8 m wide, then it would be really convenient to have a map that is 20 cm by 8 cm. In that case, one real-life meter would be represented by one centimeter on your map. What could be easier?

Here's how we will use the size of your ocean and the size of your paper to determine the best scale for you.

1. Perform the following calculations
   - **a.** Length of ocean (m) ÷ length of paper (cm)

     _____ ÷ _____ = _____

   - **b.** Width of ocean (m) ÷ width of paper (cm)

     _____ ÷ _____ = _____

2. Compare your answers in (a) and (b). You want to choose a number that is as close as possible to these numbers. If possible, choose a whole number (like 4) or a number with one decimal place (like 2.3). Choose 3 numbers that seem close to your answers and write them here:

   i. _____

   ii. _____

   iii. _____

3. For each of those 3 numbers, we will work backward to see which one gives us the best "fit" for our paper.

i. Length of ocean (m) ÷ first number

_____ ÷ _____ = _____ ⋯ this is # of cm needed on your map

Width of ocean (m) ÷ first number

_____ ÷ _____ = _____ ⋯ this is # of cm needed on your map

ii. Length of ocean (m) ÷ second number

_____ ÷ _____ = _____ ⋯ this is # of cm needed on your map

Width of ocean (m) ÷ second number

_____ ÷ _____ = _____ ⋯ this is # of cm needed on your map

iii. Length of ocean (m) ÷ third number

_____ ÷ _____ = _____ ⋯ this is # of cm needed on your map

Width of ocean (m) ÷ second number

_____ ÷ _____ = _____ ⋯ this is # of cm needed on your map

4. Decide which combination, i, ii, or iii fits best on your piece of paper. If none of these numbers seem to work, you can try additional choices. You will know you have made a "good" scale if *most* of your paper is used. If you are still having trouble finding a good fit, you can ask your teacher if it's possible to tape two pieces of paper together.

5. Once you have determined your ideal number and know what dimensions in cm are needed on your map, use those dimensions to draw a border for your ocean.

6. On the bottom right corner of your paper (outside your ocean), you should write your scale legend. It should read "1 cm = ____ m" In the blank, put the scale number your group decided to use.

7. When your "echoes" return to the whale center, the group will fill in information on Handout 6: Calculating Distances. Once you know, in meters, how far away certain objects are, you will need to convert them into distances for your map. You can do this using the following formula:

Actual Distance (m) ÷ scale number = Map distance (cm)

8. Using a ruler, and a protractor if necessary, mark the objects on your map.

HANDOUT 6

Calculating Distances

This handout will help you determine how far away objects in your "ocean" are from the whale center. Use this sheet to keep track of all the trips of each messenger.

Time Left (if using a clock)	Time Returned (if using a clock)	Seconds Messenger was away	Seconds just to get to object (half)	Walking Speed of messenger	Actual Distance to object from center	Direction (degrees) to the object	What kind of object was hit?

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